4. Quantify Military Worth

This chapter describes the concept of military worth and how quantifying military worth can prove the combat value of electronic warfare (EW) systems. It provides details of the Military Worth Method developed by the Partnership Process, explains the benefits and applications of military worth, and presents some ideas for the future of the Military Worth Method.

Military worth is the quantifiable effect of a system or its components on a military objective.

In particular, this chapter covers the following topics:

- The case for quantifying military worth
- Understanding the military worth framework
- Conceptualizing warfighter needs geometrically
- Using the Military Worth Method to quantify warfighter needs
- Using the common tools and measures that the Military Worth Method requires
- Assessing the military worth of different missions and platforms
- Making military worth assessments throughout the acquisition development cycle
- The future of military worth

Refer to Part Two of this document (Chapters 5 through 10) to see how the principles of the Military Worth Method are applied at specific points in the acquisition process.

4.1 The Case for Quantifying Military Worth

See Chapter 1, The Case for Change, for additional insights.

As we know, the challenge for the EW community is greater today than ever, due in part to more diverse and technologically advanced threats and decreasing defense budgets. We need a single measure of the military worth of EW systems to help decision makers work within a defined requirements trade space to maximize the value that systems provide to the warfighter. This measure, and the method we use to define it, needs to show how EW systems buy back airspace and so contribute to mission success.

In the past, the defense community relied on an intuitive sense that EW provided some benefit to the warfighter, even if that benefit was not quantified or was not perceived as a contributing factor to mission success. This intuitive sense is no longer enough to convince decision makers of the worth of EW systems.

In the same way, earlier investments in EW systems could be justified because they provided a backup solution to some other system. Today, we cannot afford this kind of redundant capability. Even though most people in the defense community acknowledge that EW systems provide some benefit, the fiscal climate now mandates a quantified measure of worth.

This section discusses the case for quantifying military worth in the following order:

- Quantifying military worth to achieve better solutions
- Conceptualizing military worth
- Measuring warfighter needs
- Measuring the positive contribution of EW systems

4.1.1 Quantifying Military Worth to Achieve Better Solutions

A disciplined approach to evaluating the military worth of EW systems will help us to build superior solutions to warfighter needs.

The concept of military worth is not new, but it has never before been formalized or quantified for EW systems. A disciplined approach to evaluating the military worth of EW systems will help us to build superior solutions to warfighter needs.

A superior solution to a military need is one that is better, faster, and cheaper. The last two criteria—faster and cheaper—are easy to quantify. Defining "better," however, is challenging, particularly with EW systems. If we define and quantify the military worth of solutions and use a measure that permits comparisons between EW and non-EW solutions, we can make informed decisions among alternatives that provide the greatest benefit to the warfighter.

In the past, we have often built to specifications rather than focused on objectives. We focused on specifications because we did not have a way to show how system attributes enabled the EW solution to contribute to accomplishing the warfighter's objectives. The standardized toolset and measures of effectiveness used in the Military Worth Method will help us to remain focused on objectives throughout system development.

In addition, a consistent and single measure of military worth will allow us to make disciplined trades between cost, schedule, and performance, since we will know, for instance, what we gain by an increase in cost or what we might lose by an expanded schedule.

4.1.2 Conceptualizing Military Worth

Military worth is:

> The quantifiable effect of a system or its components on a military objective.

The military worth of all systems is a function of three principle factors:

- Operational objectives achieved
- Resources expended
- Time required

These factors are functionally related and dependent on each other. These factors reflect the warfighter's perspective, since they are elements that must be considered during campaign planning. For our purposes, we need to ensure that we derive a measure that both captures this perspective and enables us to make the best possible acquisition decisions.

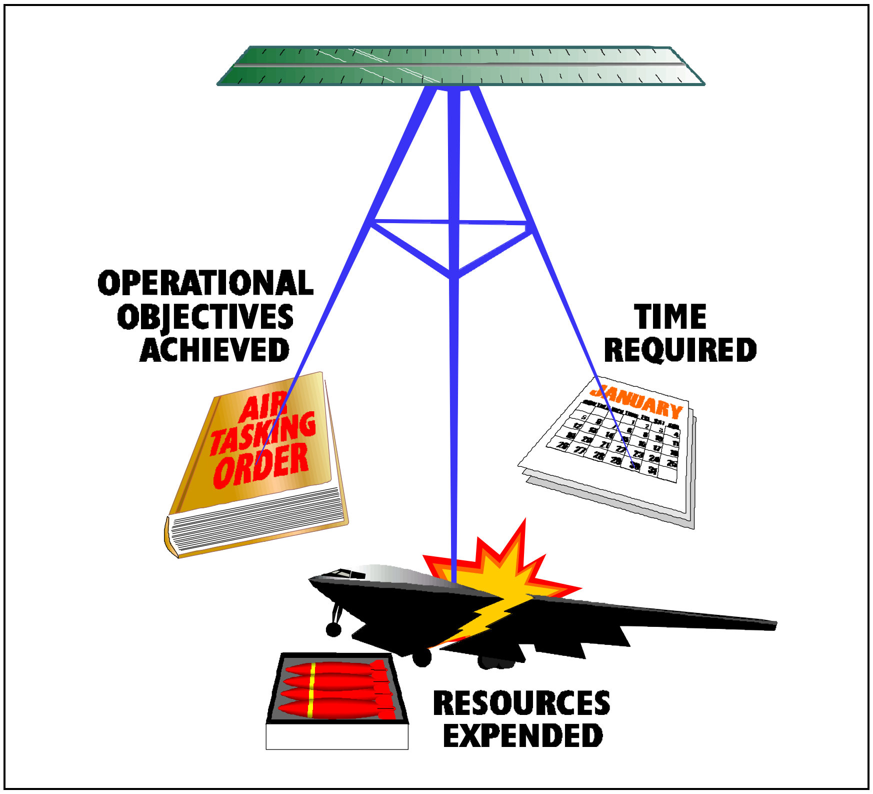

Figure 4-1. The Three Factors of Military Worth. The factors that combine to give us military worth—objectives achieved, resources expended, and time required—provide us with a single measure.

An important aspect of our understanding of military worth is that it is valid for both EW and non-EW solutions. As a result, we should be able to compare the military worth of diverse systems and allow them to compete to satisfy warfighter needs.

The following paragraphs present details about how the current Military Worth Method handles the three principal factors:

- Operational objectives achieved: Objectives are identified by the warfighter in the commander's Air Tasking Order (ATO) for a particular platform. An example of an operational objective for an electronic protect system supporting a penetrating strike aircraft is the number of targets that can be put at risk. We can currently evaluate military worth with high confidence by measuring this dimension.
- Resources expended: This factor refers to the amount of resources consumed during a campaign. The warfighter wants to minimize the resources needed to prosecute the campaign most effectively. We recognize that a key element of resources expended is attrition. In the current Military Worth Method, we handle this dimension by managing attrition—fixing it at a very low level.
- Time required: This factor reflects the number of days and hours required to achieve operational objectives. Currently, we look at a few key slices of time, selecting a few days of the campaign that represent distinctive degrees of difficulty and assume certain events in the campaign have happened. This approach allows us to take a robust look at the dynamic effects of significant battle situations.

For more information about the future of military worth, see Section 4.8, The Future of Military Worth.

Currently, we cannot calculate the function that shows the relative contribution of the three factors and their impact on military worth. Our method still allows us to quantify military worth with a high degree of confidence. In our method, two of the factors—resources expended and time required—are held constant and the third—objectives achieved—is the single variable. The resulting measure of military worth is useful and reliable because objectives achieved is both the most significant dimension and the one we can measure with the most confidence.

In the future, we may develop a method for determining military worth that provides more certainty because it fully allows the other two factors—time and resources—to vary. Because it would reflect the complicated situations in which a warfighter makes decisions, this measure should maximize our confidence that our acquisition efforts respond to the warfighter's needs.

We will, however, always need a single measure of military worth that is useful to the acquisition decision maker. This single measure forms one dimension of the acquisition trade space, as depicted in Figure 4-2.

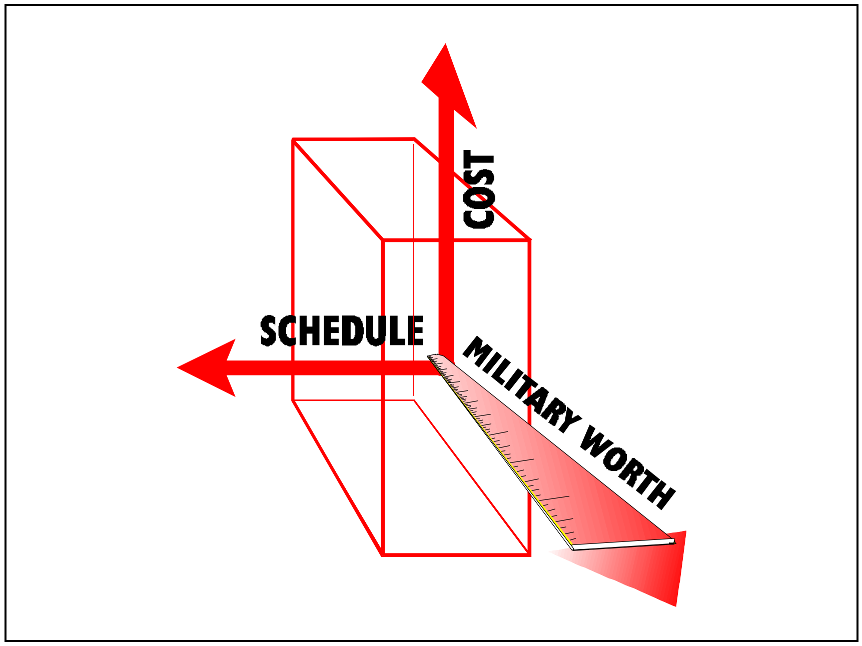

Figure 4-2. The Requirements Trade Space. Military worth forms one dimension of the three-dimensional trade space, which also includes the cost of the item we develop and the time required to make it operational.

Working within the constraints of this trade space will be the focus of much of Part Two of this document. In this chapter we will elaborate how the military worth axis is derived and how it helps to guide decisions during an acquisition.

4.1.3 Measuring Warfighter Needs

The warfighter needs a measure of military worth that helps commanders decide whether they should employ weapon assets in a given scenario. Acquisition decision makers need this measure in order to make trades within the requirements trade space among performance, cost, and schedule.

The traditional measure of effectiveness for an EW system is reduction in lethality (RiL), a measure that indicates a reduction in negative consequences. However, a measure in terms of RiL is difficult to connect with any desired military outcome. Additionally, because of the way RiL is calculated, we cannot make a direct correlation between it and higher-level (even negative) consequences, such as attrition.

According to a recent article in Aviation Week and Space Technology,

> The RiL criterion has no significance for a USAF commander who wants to know how many aircraft need to be sent on a mission to assure target destruction, how many of these will return and how EW systems will affect these numbers.

RiL simply calculates the change in lethality, without specifying any missions or targets. A valid measure of the military worth of EW systems could prioritize areas that the warfighter wants to reach and would indicate which areas are made accessible with an EW system.

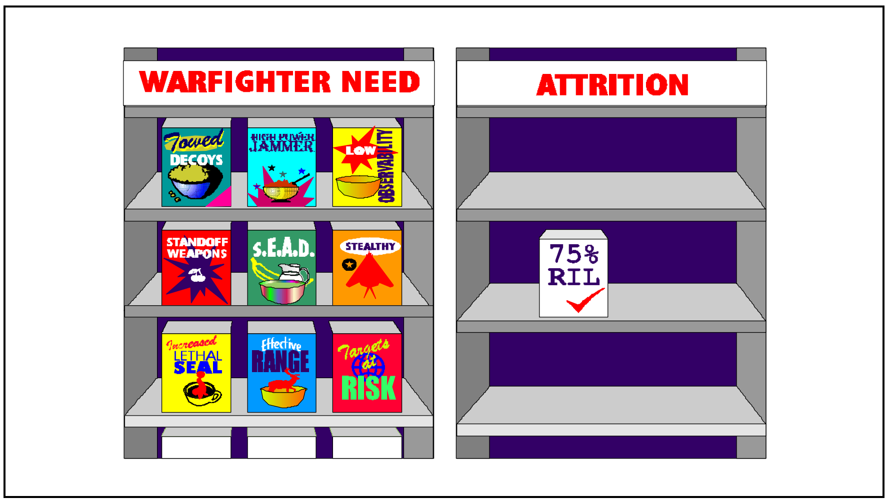

Figure 4-3. Warfighter Need Versus Reduction in Lethality. By responding to warfighter needs and showing how EW systems allow us to buy back airspace, we can compare a variety of options and provide better and more robust solutions.

The shortcomings of RiL as a measure of military worth can be understood in this way: Assume that an EW system reduces the number of times an aircraft is hit on a single pass from five to four times. In this simple example, the EW system has produced a RiL of 20%.

This change, however, does not indicate a benefit to most commanders, who would argue that four hits represent an unacceptable risk. In any case, the measure still indicates that the platform was destroyed on each pass whether the EW system was in use or not.

For all these reasons, RiL fails to provide adequate insight for decision makers. That is, it fails to provide information about airspace that is made safe by a system and which enables the warfighter to complete missions. Its calculations average all passes over a range and so does not indicate what we will call the geometric effect of EW systems. Consequently, the warfighter cannot know where the EW system provides benefit and so cannot use RiL to plan missions. Additionally, RiL is of limited use to decision makers, since a change in RiL cannot be directly tied to higher-level objectives.

Even if RiL could correlate to a reduction in attrition, it would not provide the insight demanded by today's decision makers. Since an attrition level can never be low enough, this type of measure does not indicate how we should deploy our military assets.

We need a measure that helps commanders decide whether they should employ weapon assets in a given scenario.

Therefore, reduction in lethality is not a useful measure for warfighters who must plan and execute missions. We need a measure that helps commanders decide whether they should employ weapon assets in a given scenario, and RiL (or any other measure that shows only a reduction in negative consequences such as attrition) does not provide that kind of insight.

4.1.4 Measuring the Positive Contribution of EW Systems

We must define a measure that correlates test information with warfighter needs.

The military worth measure must be stated in terms of mission needs and mission success—how many objectives warfighters cannot currently achieve and how many more they could achieve through the contribution of a particular system. In particular, the method used to quantify the military worth of a system must allow us to perform the following tasks:

- Ensure that the voice of the warfighter is heard throughout the acquisition process.
- Provide a solid analytic foundation for deriving requirements.
- Derive a single measure of a system's military worth that is useful for acquisition decision makers.
- Create a trade space from which potential solutions to mission deficiencies will emerge.
- Enable a comparison of the combat worth of dissimilar systems and weapons.

- Encourage better, more informed choices among alternative solutions.
- Detect any deviations from the warfighter's requirements early in the process—not after the system has been built.

The Military Worth Method developed by the Partnership Process allows us to accomplish all of these goals. Because military worth is stated in non-EW terms, it enables acquisition personnel to make comparisons between competing solutions. Then we can choose the best solution of the warfighter's needs based on empirical and quantifiable evidence.

4.2 Understanding the Military Worth Framework

The Military Worth Method operates within a framework that allows us to link high-level strategies to lower-level tasks and functions. Within this framework, all acquisition processes work toward achieving goals at the top level—national security objectives.

With national security objectives at the top, the framework expands downward to encompass national military objectives, campaign objectives, operational objectives, operational tasks, and operational capabilities. The bottom of the framework is supported by two lower levels—operational functions and technical attributes. As we move from one level to another during the acquisition process, we should be able to show how our decisions connect to the upper levels of the framework.

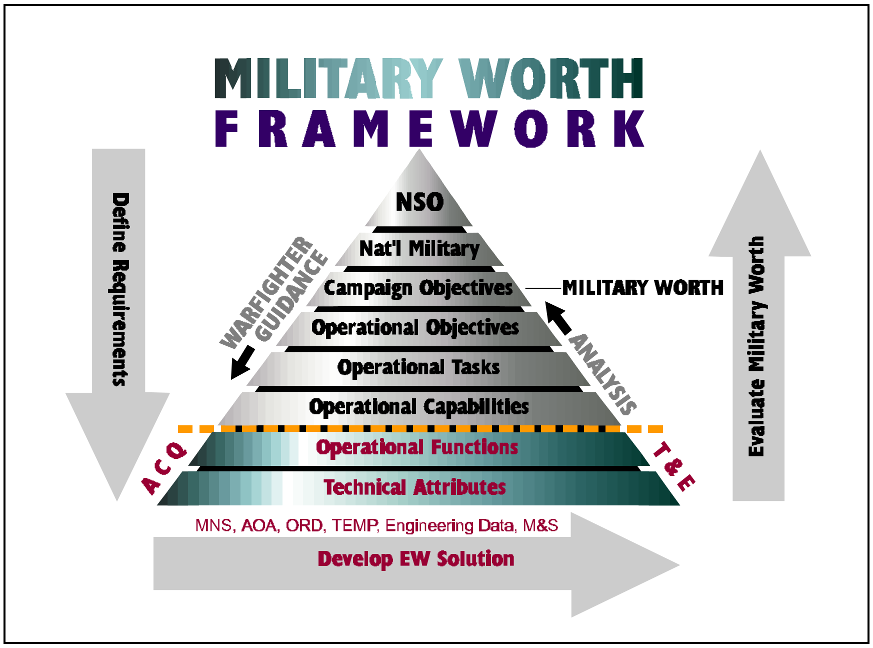

Figure 4-4. The Military Worth Framework. By using the Military Worth Method, we can ensure that even the technical attributes of a system support campaign objectives.

The top levels of the military worth framework, from National Security Objectives to Operational Tasks, were defined by the Joint Strike Fighter program as follows.

- National security objectives: National security objectives (NSO) are defined in view of threats to our fundamental goals. The President, with the aid of the National Security Council (NSC) and other advisors, articulates national security objectives. These objectives are formulated and defined in light of U.S. interests and the threats to these interests and opportunities for advancing those interests.

- National military objectives: National military objectives are those objectives to be achieved through the use of military resources. The national security objectives prompt planners to adjust and refine subordinate objectives. National military objectives describe how the military component of national power is to be applied to maintain or attain national security objectives.

- Campaign objectives: Campaign objectives are regionally specific. Regional or theater objectives cover a spectrum of military employment, with regional commanders (CINCs) developing plans for deterrence, limited operations, and regional conflict. Campaign objectives define desired outcomes of regional military preparations or military campaigns.

- Operational objectives: To achieve desired outcomes contained in the campaign objectives, regional commanders must orchestrate the preliminary deployments and, if necessary, the employment of the many different force elements at their disposal.
- Operational tasks: Operational tasks form the fundamental building blocks of military actions and are defined as "militarily significant pieces of work that do the enemy direct harm, which in turn are measurable in terms of his reduced capability to achieve his objective(s)." Each operational task has a target set associated with it.

The lower levels of the framework reflect capabilities, functions, and tasks that must be attained and accomplished to support the higher level objectives.

By ensuring the connection between the levels of this framework, the Military Worth Method ensures that all participants in an acquisition contribute to high-level objectives and functions. Our method for securing these links includes:

- Responding to the voice of the warfighter
- Stating military worth in warfighter terms

4.2.1 Responding to the Voice of the Warfighter

Military worth for EW systems is stated at the level of campaign objectives, which defines our capability and needs for particular threat scenarios. Campaign objectives are determined by the warfighter at the highest level, the theater commanders in chief (CINCs). Our Military Worth Method enables that warfighter guidance to resonate as we define a particular solution to a deficiency and determine the optimal functions and attributes of that system.

Once campaign objectives are defined, warfighters continue to lead the articulation of campaign goals. They provide their expertise on how best to fly missions that accomplish the CINC's objectives, based on system capabilities, target locations, and identified threats. When these mission plans are complete, we can identify the warfighter's needs, which are the missions they cannot accomplish with current technology.

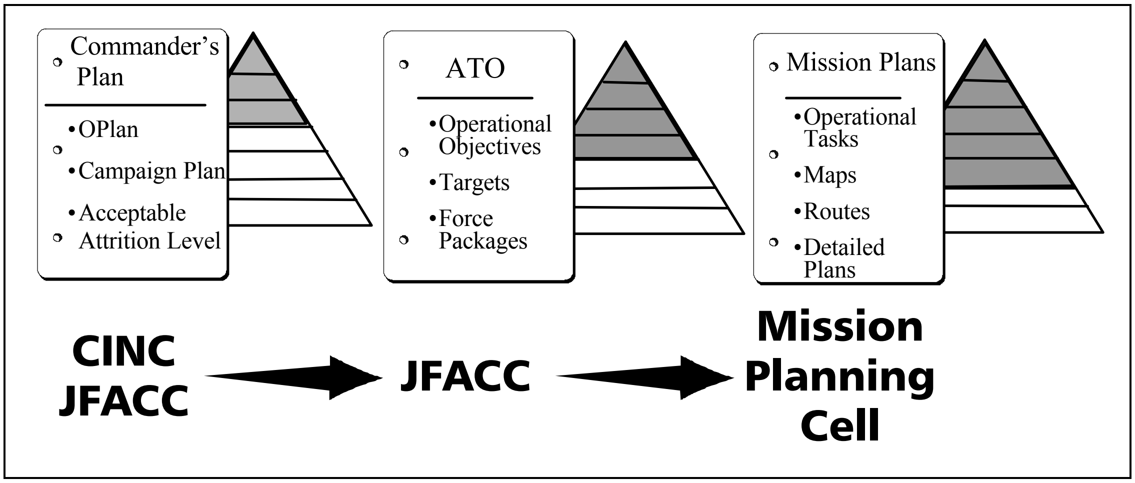

Figure 4-5. Warfighter Involvement in Mission Planning. As we move from high-level goals to specific mission plans, the flow of information and decision making must keep the warfighter's voice at high volume.

When the warfighter's needs are quantified, they are communicated to government and industry, who should work together to address and meet those needs. As the best solution evolves and develops, it is tested to ensure that the solution meets warfighter needs.

4.2.2 Stating Military Worth in Warfighter Terms

The Partnership uses the mission commander's measure of effectiveness as the basis for calculating military worth—Air Tasking Order accomplished.

To quantify the system's contribution to achieving campaign objectives, we must be able to communicate in terms that reflect the goals and needs of the warfighter. As discussed in Section 4.1.2, Conceptualizing Military Worth, the Partnership uses the mission commander's measure of effectiveness as the basis for calculating military worth. This measure can be found in the Air Tasking Order (ATO) for a particular platform, which states specific tasks that must be accomplished to achieve operational objectives. The generic measure of military effectiveness is ATO tasks accomplished.

We use targets at risk as the example of ATO tasks accomplished throughout this document.

In the case of penetrating strike aircraft, the Military Worth Method uses targets at risk (TAR) as the measure of ATO tasks accomplished. This measure of TAR expresses the percentage of enemy targets that can be threatened during a campaign. Specifically, it measures the ability of warfighters to get their platforms to a specific point in space so they can deploy munitions and return safely to home base. We use targets at risk rather than targets destroyed because targets destroyed depends on factors that an EW system cannot affect.

For aircraft involved in missions that have an objective besides destroying a target, we will use the objective stated in the ATO as the measure of military worth. The following are possible alternative measures:

- Drop zones at risk for supplies and paratroopers
- Threat radars at risk
- Targeted systems "surveillable"
- Refueling tracks supportable
- Air interceptors at risk
- Sorties properly controlled

In any case, the measure of military worth will be directly linked to campaign objectives and will indicate the contribution of an EW system to the success of that mission.

Throughout this document, we use TAR as our example. TAR can show the contribution of a variety of systems and operations to achieving campaign objectives, even if the particular activity plays only a supporting role in an attack.

The measure of ATO tasks accomplished is an appropriate campaign level military worth measure because it provides a single metric for a variety of military systems. This single metric allows us to quantify and compare the value of dissimilar systems and even permits an accurate assessment of the contribution of supporting elements that assist the primary forces in a mission. The military worth measure recognizes that warfighters can achieve more objectives if they can respond to or defeat the threats that could interfere with their missions.

4.3 Conceptualizing Warfighter Needs Geometrically

This section explains how the Military Worth Method characterizes the warfighter's needs geometrically and illustrates the warfighter's need to get to particular points in space to accomplish a mission. This characterization not only allows a comparison between different classes of solutions but permits a full analysis of which threats can be countered by a change in tactics and which demand a materiel solution.

This section covers the following:

- AFSAA's new look at the military worth question
- The Military Worth Method
- The role of low-kill offsets and P_k grids

4.3.1 AFSAA's New Look at the Military Worth Question

The Air Force Studies and Analyses Agency (AFSAA) has developed methods and tools that allow us to quantify the number of ATO tasks accomplished that are enabled by employing EW systems.

As discussed in Section 4.1.3, Measuring Warfighter Needs, the standard measure of EW has been RiL. This measure gauges only a reduction in negative consequences, and as a result, does not give a true sense of the military worth of a system. As we discussed in the previous section, the ATO tasks accomplished measure gauges the contribution of systems to mission success.

AFSAA realized the limitations of measuring EW systems with RiL during a study conducted on the B-1B bomber. The agency found that the true military worth of a system can be more accurately measured when stated in positive terms (numbers of objectives achieved) rather than in negative terms (RiL).

Col George "Ed" Crowder, Chief, Air Force Applications Division, AFSAA, reported these findings in an article published in the Journal of Electronic Defense.

> When we'd done our study, the B-1 without an EC [electronic combat] suite experiences the same attrition as a B-1 with an EC suite [because attrition was managed in both cases]. The difference is the one with an EC suite is able to attack a far greater range of targets. We think that by connecting EC to the ability to attack targets, we have finally gotten at the military worth question.

In other words, evaluating the reduction in attrition did not convey how the EC suite contributed to the mission success of the B-1, but measuring the number of targets put at risk demonstrated the value of the EW systems.

This AFSAA study laid the groundwork for a truly useful measure of the military worth of EW systems and provides a new look at an old problem. The major breakthroughs of this approach are the following:

- We look at mission-level effects rather than single engagements.
- We state the effect of EW systems in terms that allow us to trade against other variables. We don't want to trade against attrition, since attrition can never be low enough, but we can trade against targets or tasking orders accomplished.

Though the Military Worth Method is based on AFSAA's work, it modifies and expands its insights. In particular, as we discuss in Section 4.3.2, The Military Worth Method, the Partnership finds an alternative to transforms, the way that AFSAA addressed the feasibility issue.

4.3.2 The Military Worth Method

The Partnership adapted and adopted the method developed by AFSAA to create the Military Worth Method, which provides us with a means of quantifying the effects of EW systems. The Military Worth Method provides a geometric view of how threats can interfere with mission success. This geometric view enables warfighters to determine which threats they can reasonably avoid by using tactical measures (such as by flying higher) and which threats cannot be eliminated through a change in tactics.

Figure 4-6 shows why we need a measure of effectiveness that indicates where an aircraft can fly. In this scenario, the warfighter thinks of getting to particular points in space—the five triangles at the top of the picture—and needs to defeat the three kinds of threats that may prevent a successful mission.

The threats (labeled A, B, and C) are indicated by three-dimensional bubbles, suggesting that at certain altitudes these threats create an unacceptably high probability of kill. The triangles at the top of the graphic indicate targets, and the planes at the bottom of the graphic represent missions.

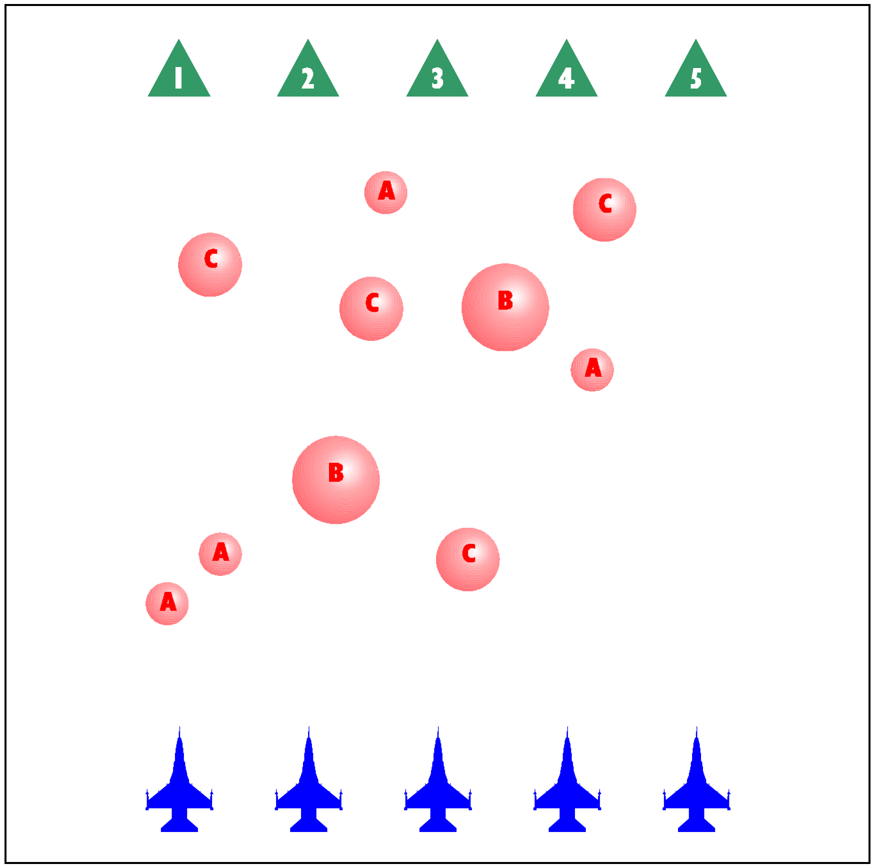

Figure 4-6. Threats and Targets. The triangles at the top of this graphic represent targets that the warfighter has identified, and the circles, labeled A, B, and C, represent threats.

As shown in Figure 4-6, some threats can be avoided by planning missions around them, while others continue to prevent successful completion of a mission. Avoidable threats are represented in Figure 4-7 with a letter, while the unavoidable threats, which continue to present an unacceptable probability of kill, are represented by a circle.

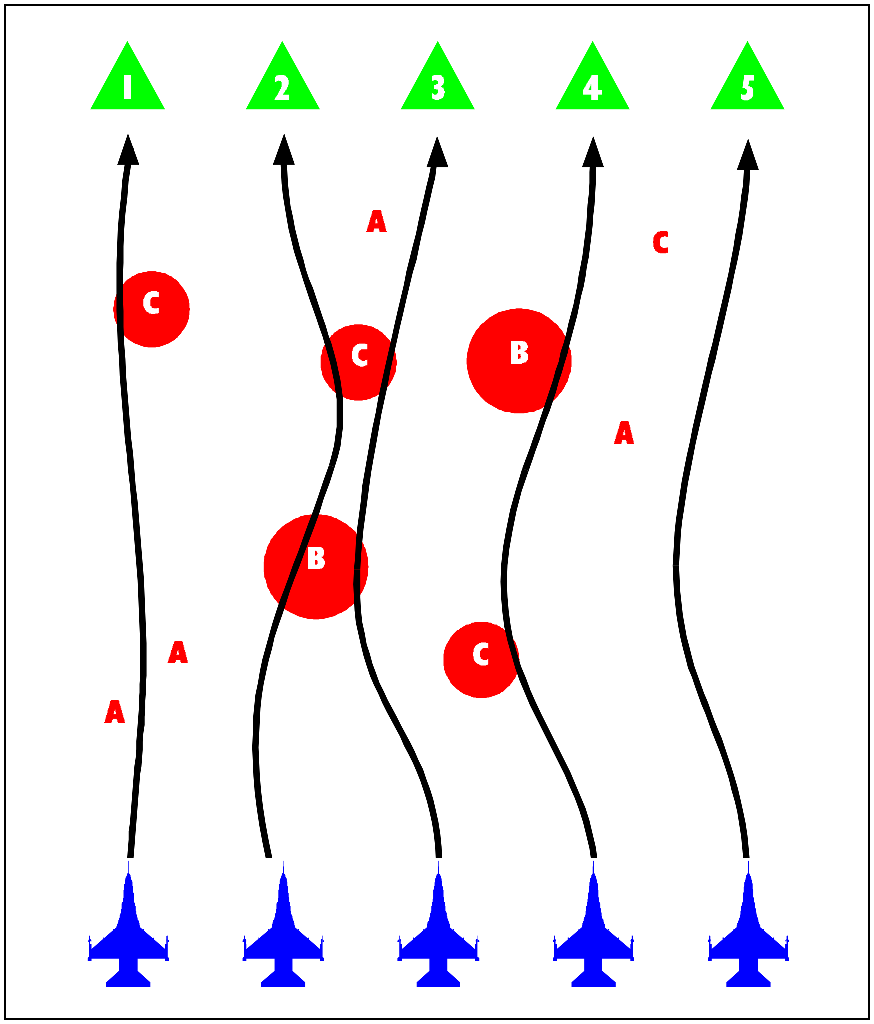

Figure 4-7. Tactics and Materiel Solutions. When the flight paths have been determined, we know which threats are avoidable through tactics (such as threat A) and which require some materiel solution.

Note that the three-dimensional bubbles of Figure 4-6 have been replaced by two-dimensional circles in Figure 4-7. This change indicates that the warfighter has selected an altitude, and so the probability of kill need only be calculated for that altitude.

We should also note that none of the threats in category A poses a threat once mission planning is complete. Therefore, any system that only reduces A's effectiveness will not be useful in completing missions.

The threats that cannot be avoided through a change in tactics demand some kind of materiel solution. Once the warfighter has identified which threats cannot be countered by tactical measures, government and industry should work together to develop materiel solutions to counter the remaining threats. We need to collaborate to find potential solutions that can help the warfighter complete more missions in a variety of campaigns.

We want to show how EW buys back airspace from threats.

For EW systems in particular and air combat in general, the entire issue of military worth relates to getting to a particular point in space so that the warfighter can accomplish a mission. With our geometric view of the function of EW systems, we have developed a method for determining the benefit derived from EW systems. In other words, we can calculate how well they help the warfighter get to places that, without EW, are unreachable.

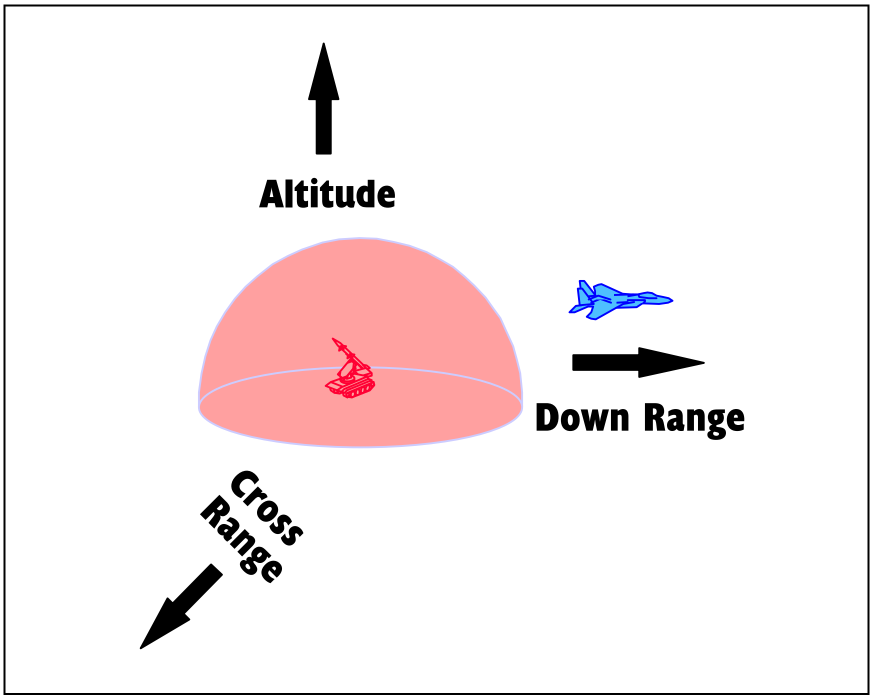

Figure 4-8. A Geometric View of Threats. A geometric view enables warfighters to determine what airspace has been bought back by an EW system.

Evaluation Accuracy

The Military Worth Method includes sensitivity analyses for a variety of factors which give us a certain degree of confidence in the result.

The Military Worth Method allows us to calculate the lethal range of the threat with some degree of confidence. We realize that this method uses models and makes assumptions, and the results are only as good as the assumptions and models that we use. The models we use are subject to the same verification, validation, and accreditation processes as existing models, and the data we use must be verified, validated, and certified according to standard practices.

To indicate high and low areas of confidence in our analysis, the Military Worth Method includes sensitivity analyses that test a variety of assumptions, thus giving us a certain degree of confidence in the results.

Our measurement of military worth will rely on statistical sampling during the test and evaluation processes. While sampling always presents the possibility of statistical errors, we can minimize these errors by increasing the number of measurements and understanding the relationships between measurements. In addition, whenever military worth is measured, the confidence factor and expected accuracy will also be quantified.

Finally, given recent advances in modeling and simulation (M&S) supporting EW developments, test and evaluation no longer bears the burden of having to fully characterize system performance. Testing can now concentrate on validation of a subset of M&S results, especially those of low confidence. M&S that has been validated can then be used to establish the full performance envelope.

How Military Worth Addresses Feasibility

Though the Partnership's Military Worth Method uses AFSAA's geometric view of threats and builds on much of its work, we do not measure the effect of systems with transforms.

Transforms provide an estimate of the difference between a baseline or "dry" capability and the amount of capability needed to defeat a given threat at a given range. The transform allowed AFSAA to answer feasibility questions and establish minimum requirements. In addition, transforms permitted analysts to isolate the electronic countermeasure contribution of an EW system.

While an analysis of transforms is useful in some situations, such as when the military needs to determine whether a particular solution is technologically feasible, this kind of comparison presents two problems:

- The existing baseline is only applicable to similar systems. (For example, one cannot accurately predict the capability of a decoy by transforming the capabilities of self-protection jammers.)
- Lacking other data, the transform assumes a linear relationship between EW capability and effectiveness. This assumption is likely to be an approximation and we should replace it with better data when we better understand the characteristics of the solution.

The Military Worth Method bridges the gaps that transforms create.

The Military Worth Method bridges the gaps that transforms create:

- First, by using the common baseline of targets at risk, rather than an existing system's capabilities, all solutions can be accurately assessed by how many more objectives they help warfighters achieve.
- Second, the Partnership Process lets our industry partners assess the feasibility of solutions, rather than restricting the solution space to what the government thinks is possible.

By assessing these solutions with industry's insight into their detailed capabilities, the Military Worth Method attains the best understanding of what each potential solution brings to the warfighter without relying on mathematical simplifications.

4.3.3 The Role of Low-Kill Offsets and P_k Grids

To indicate how more targets are put at risk by EW systems, the Military Worth Method provides two ways of representing threat lethality:

- A simple representation of threat range, offset, and probability of kill
- A high fidelity, comprehensive representation of threat range and probability of kill (P_k)

Both of these representations are useful in determining how much a threat's lethal area must be decreased to ensure mission success. The range and offset measure provides quick-turn information when we have less detail available. P_k grids are used when we have a more complete data set.

Defining Key Terms

Before proceeding further, we need to specify our use of certain terms. Throughout the remainder of this document, we will use a set of terms to describe how we determine the spatial and geometric effects of an EW system. Some of these terms are described as follows:

- Encounter: Each time an aircraft enters a threat's lethal envelope.
- Engagement: Each time a threat takes a shot during an encounter. There may be zero, one, two, or more engagements for each encounter.

- Grid P_k: The probability an aircraft dies given it enters a grid cell in space relative to a specific threat. This value does not necessarily assume an engagement has occurred. In general, when we refer to P_k in this document, we refer to grid P_k .
- Grid P_s: The probability an aircraft lives given it enters a grid cell in space relative to a specific threat. Grid P_s is equal to (1-Grid P_k).
- Encounter P_k: The probability an aircraft dies given it enters a threat's lethal envelope. This value implies an aggregation of grid P_k along a flight path inside the threat's lethal envelope.
- Encounter P_s: The probability an aircraft lives given it enters a threat's lethal envelope. This value implies an aggregation of grid P_s along a flight path inside the threat's lethal envelope.
- Engagement P_k: The probability an aircraft dies given a threat takes a shot.

These terms help us describe the effects of an EW system on mission success and enable distinctions between the Military Worth Method and earlier attempts to express EW effectiveness.

Representing Threat Envelope Shrinkage with Offsets

Because our measure of military worth provides a consistent measure of the system's performance, we can calculate the military worth of a particular solution throughout its development. We will perform detailed and comprehensive simulations of threats and the effectiveness of our solution at specific intervals, but to ensure the system is constantly on the right track, we also need a faster and less resource-intensive means of performing similar analyses.

RiO is the closest fly-by distance from the threat while meeting or exceeding a defined probability of survival.

Reduction in low-kill offset (RiO) is simply the closest fly-by distance from the threat while meeting or exceeding a defined probability of survival. Using this concept, we can create a useful model that gives decision makers enough information to make insightful decisions about the effect of specific design choices.

RiO implies a particular flight path and is not the same as distance from the threat. For example, in the following graphic, points A and B are the same distance from the threat (X), but the offset range for A = A while the offset range for B = 0. This distinction is important because the P_k of A is generally not equal to the P_k of B.

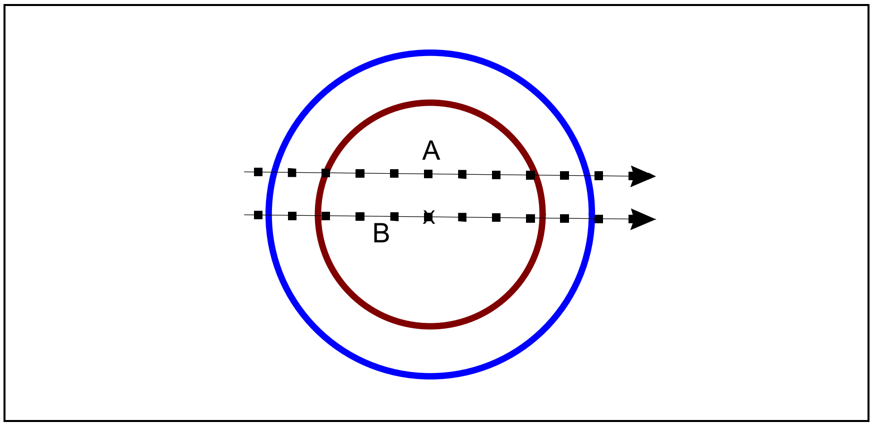

Figure 4-9. Offset Range. This graphic shows two points, A and B, which are the same distance from the threat but represent different offsets.

In Figure 4-10, we see that threats B and C must be reduced by a particular amount for the warfighter to complete every mission.

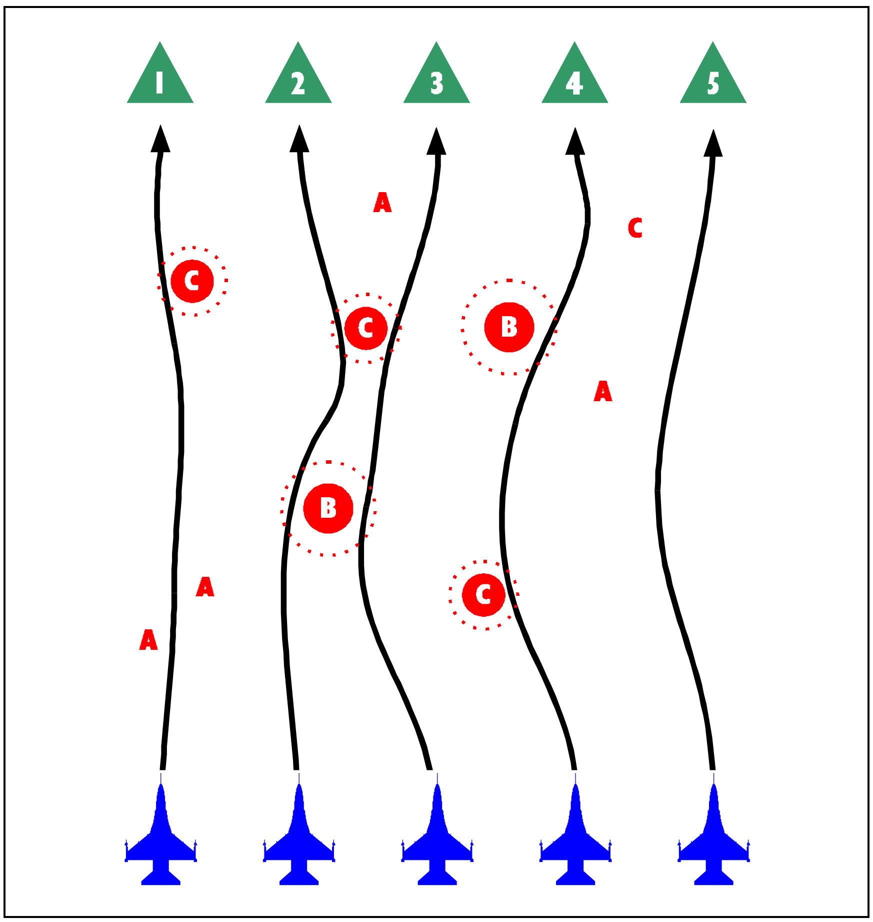

Figure 4-10. Offset Reduction. This graphic indicates that threats B and C must be reduced by a certain amount to allow missions 1 through 4 to be successful.

By calculating threat envelope shrinkage with offsets, we can achieve a simple representation of what we need an EW system to do. In this example, we need to create a certain amount of space around threats B and C in order to get to targets 1 through 4.

Several points can be observed from Figure 4-10:

- Grid P_k generally decreases as distance from the threat increases.
- There is a point at which P_k falls to zero. This is, for our purposes, the maximum kinematic range of the threat's missile. While others may use a more precise definition of maximum kinematic range, this difference does not affect our conclusion.

This graph is a simplification that represents the notional relationship between P_k and range.

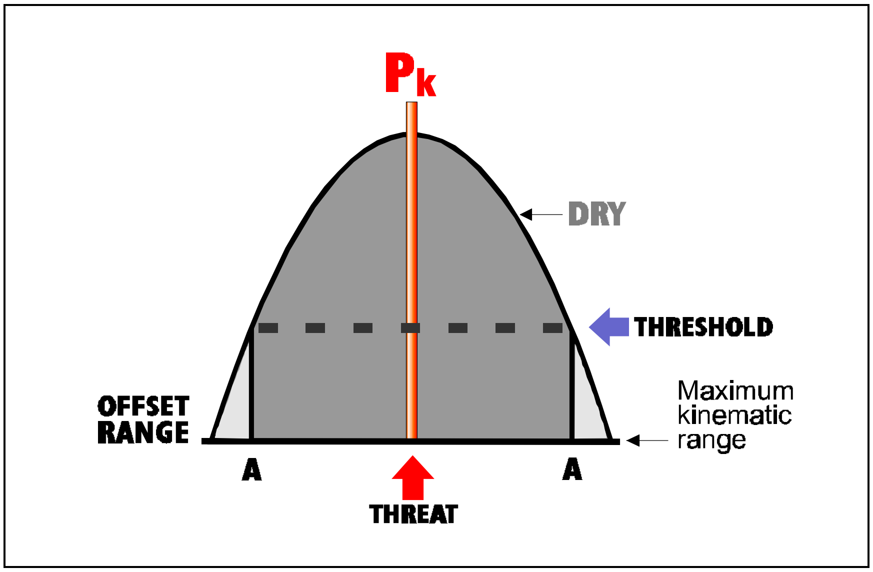

Figure 4-11. P_k Versus Range. A given threat's P_k decreases as the distance between it and a dry (non EW-equipped) platform increases. The distance from A to A represents the diameter of the dry threat ring.

Figure 4-11 is an example of a dry case—the platform does not employ an EW system. Depending on the nature of the threat, the P_k profile may differ, but we can always expect a correlation between the platform's proximity to the threat and its P_k.

Notice the P_k threshold, represented by the dashed line. This threshold could correspond to an acceptable level of attrition, which the theater commanders in chief could specify based on historical data. Alternatively, it might represent a threshold used by the system's evaluators. In either case, the threshold indicates a value for P_k below which system performance is considered satisfactory. The use of thresholding establishes a specific range at which the threat's lethality is judged acceptably low.

Beyond this threshold, the warfighter will decide that the threat poses too great a danger and so the target the threat protects will not be put at risk. As a result, the warfighter cannot accomplish missions that are required to achieve campaign objectives.

Now consider what happens when the platform employs an EW system. Figure 4-12 shows the original P_k relationship, as well as a new line that represents the reduction in P_k achieved by the EW system.

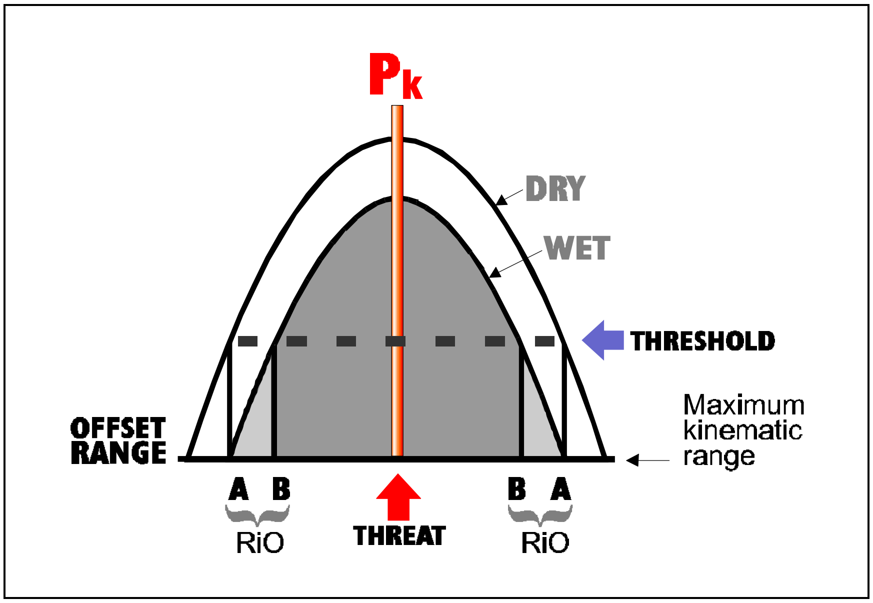

Figure 4-12. RiO Due to EW Solution. A "wet" (EW-equipped) platform has a greater range of targets than a "dry" platform. P_k still varies with distance from the threat, but EW reduces the threat's offset.

The important points on this graph are where P_k crosses the threshold, for both dry and wet platforms. The difference between these two points is the shrinkage in the threat envelope—or offset reduction—achieved by the EW system.

This graph indicates the following two important effects of an EW system:

- In this example, the wet P_k function crosses the threshold at a smaller range than the dry P_k. The distance from B to B is the diameter of the wet threat ring.
- The wet P_k (with EW) is lower than the dry P_k for the entire range of the threat. (This is the possible net effect of an EW system. Actual reduction in P_k for a particular range will depend on the nature of the threat. In some cases, there may be points where the P_k is not reduced or may even increase.)

Unlike measuring RiL, which usually averages data from many points and flight paths, the Military Worth Method does not average the results to arrive at the reduced lethal area. Rather, it shows the geometric effect of reducing a threat's range by gathering information about the threat's offset at specific points.

Because RiO shows the reduction in the lethal range of a threat—that is, the point where the P_k curve crosses the threshold—we can demonstrate the geometric benefit of EW. If this threshold is linked to the theater commander in chief's acceptable level of attrition, then the range indicates the border of the safe area of flight.

We call the closest point that our aircraft approaches the threat with a specified encounter probability of survival the low kill offset. We set the encounter P_k to a low but non-zero value to account for the possibility of outlying threats that could still hit our aircraft beyond the offset range. Thus, our measure of EW effectiveness for 1-v-1 engagements is RiO achieved when EW is used.

Representing Threat Shrinkage with P_k Grids

Until now, our discussion has revolved around simple graphs of P_k versus range and graphs that show the threat as a simple circle. In reality, P_k has meaning at every point in the three-dimensional space included in the threat's kinematic range. The x, y, and z axes of the three-dimensional space are usually called down range, offset, and altitude. Unlike the graphs presented in Figures 4-11 and 4-12, P_k grids allow us to represent two dimensions—range and offset—at a particular altitude.

Figure 4-13 shows the P_k of a specific altitude in different down range and offset cells with different colors (or shades of gray). By layering several P_k "slices" we can depict altitude with separate color charts. Figure 4-13 is an example of two P_k grids, showing both the dry case (without EW) on the left and the wet case (with EW) on the right.

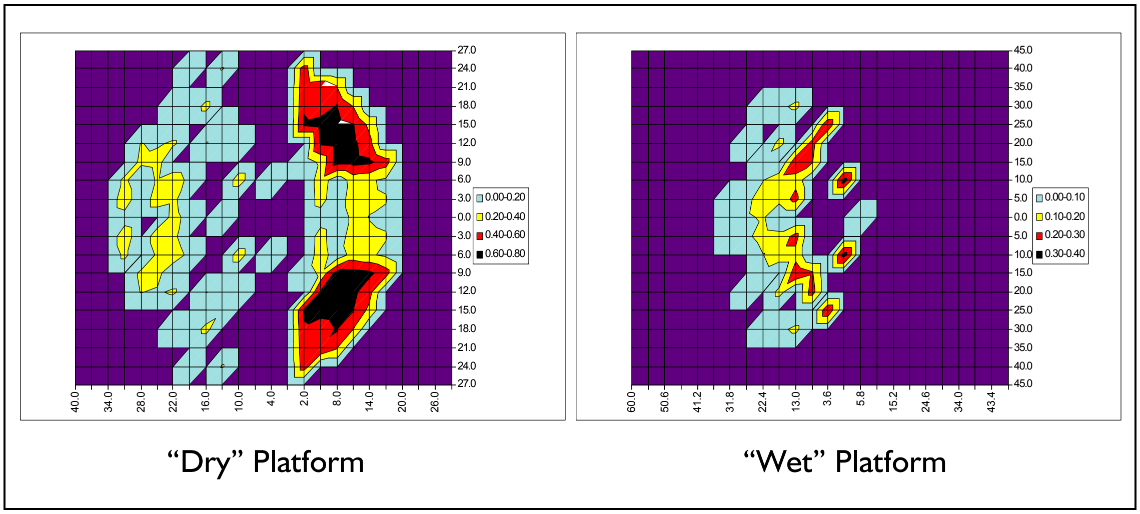

Figure 4-13. P_k Grids. While RiO simply shows that P_k decreases the range of the threat, P_k grids indicate the more complex effect of an EW system.

These comprehensive P_k grids raise several issues that were not evident in the simplified RiO graphs:

- The actual relationship between P_k and range is complex, varying with aspect angle, range, and several other factors.
- The total effect of EW is not simple reduction in low-kill offset. P_k areas also change shape and their level is reduced, but it should be clear that "shrinking rings" is a simplification of the real behavior.

Adapting the graphics we used earlier in our discussion, we can see that the planned flight paths cross the threat's P_k at certain points. The threats in Figure 4-14 without P_k grids do not present an unacceptable level of P_k.

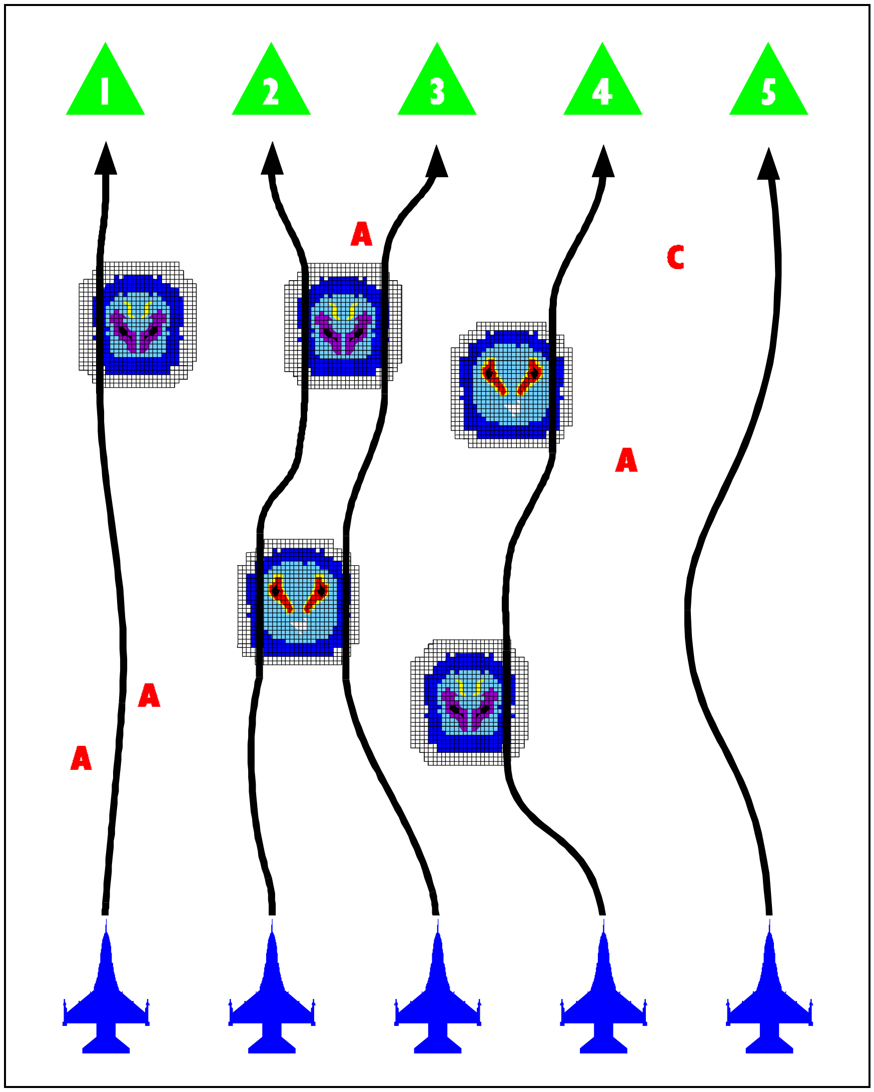

Figure 4-14. Flight Paths and P_k Grids. In this graphic, we see that the P_k of threats at a particular altitude pose an unacceptable level of P_k.

When we have determined the locations where P_k values exceed our threshold, we can develop a system that allows us to counter these threats and achieve our mission objectives. In the graphic below, we see the effects of an EW system on the shape and size of P_k grids. The white squares indicate the threat's range without an EW system enabled.

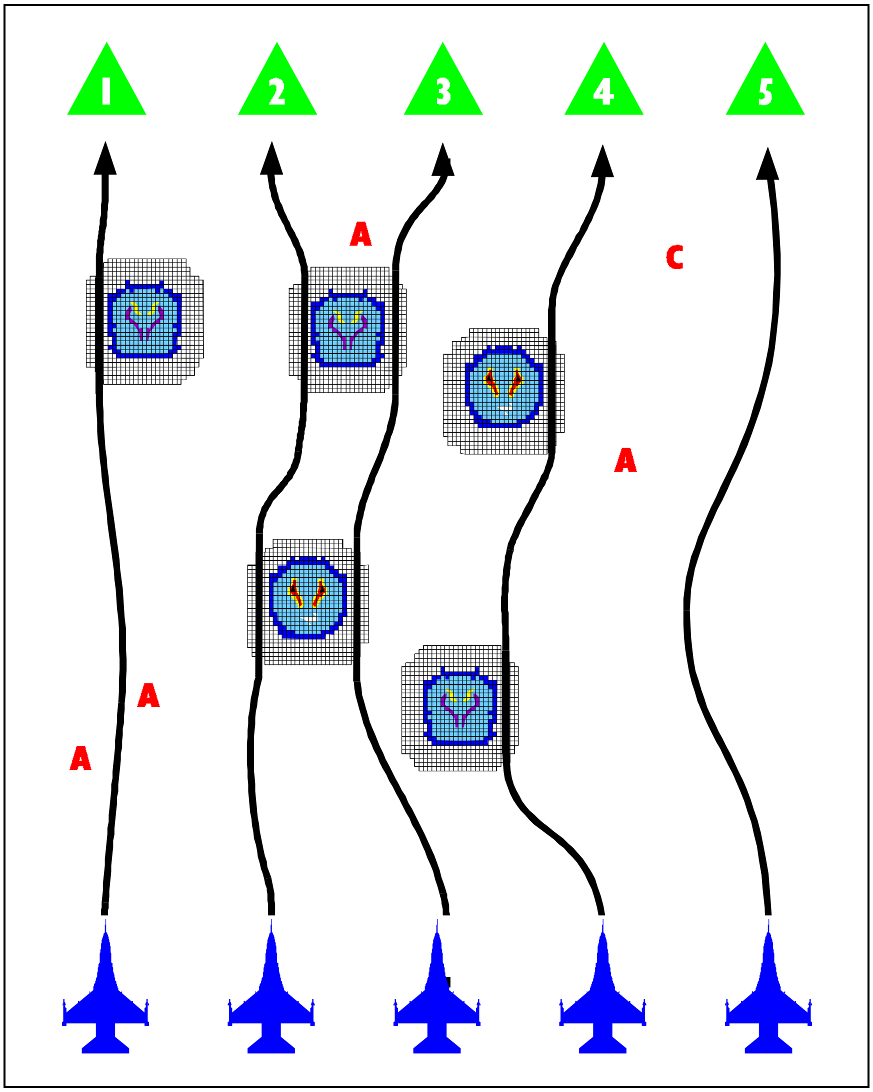

Figure 4-15. Reduction in P_k. In this graphic, the P_k grids have been changed and reduced due to the effects of an EW system.

Both offsets and P_k grids help us to implement the Military Worth Method. When more detail is available and specific information is required for the computation, P_k grids are used because they provide the highest-fidelity representations of threat capabilities. At other points in the process, such as when a quicker turnaround is required or when less detail is available, the Military Worth Method incorporates the offset measure.

4.4 Using the Military Worth Method to Quantify Warfighter Needs

This section describes the steps we follow to quantify military worth. The example we use in this chapter is very simple. Planning for actual missions in realistic scenarios would require managing much more data. The method we describe here is the foundation of the new process for EW acquisition we describe in Part Two of this document.

The data and tables described in this section provide the basis for the deficiencies identified in the Mission Needs Statement (MNS) and are the foundation for the entire acquisition process—defining and conveying requirements, comparing alternatives, developing a solution, and evaluating the effectiveness of our solution.

The following subsections will cover the five steps we use to model missions and compile the data that quantifies warfighter need and the effectiveness of solutions. The steps are:

- Gather mission data
- Create a mission success table
- Create a table of all solutions
- Create a TAR trade space table
- Analyze the mission data

4.4.1 Gather Mission Data

The first use of modeling and simulation in the Military Worth Method is to create an accurate simulation of the mission the warfighter wants to accomplish.

In order to illustrate our point, this example is very simple. Normally, we would need to work with much more data.

For the purposes of illustration, assume that the Electronic Warfare Center of Excellence for Analysis (EWCEA) has obtained ATOs for specific threat scenarios from the warfighter. (For more information about EWCEA, see Chapter 6, Establish the Requirements.) Based on these plans, we know that five targets need to be degraded or destroyed to support the campaign. For our simple example, EWCEA plans five missions—one target per mission.

In the next step, EWCEA consults with a mission planning cell, asking warfighters how they would fly each of the five missions. The warfighters consider the area of operations, the targets, the threats, and the geometric range of the threats, then provide flight plans and strategies for how they would fly the missions.

The example we have been using shows three classes of threats (A, B, and C) protecting the five targets.

Given this data and warfighter guidance, EWCEA is ready to analyze the problem and determine how an EW system might contribute to a solution.

4.4.2 Create a Mission Success Table

The tables in this section correspond to the pictures in Figures 4-6, 4-7, 4-10, 4-14, and 4-15.

Incorporating the five flight plans provided by the mission planning cell, EWCEA uses a mission-level simulation to determine the success or failure of each mission. In this context, success is achieved if the aircraft reaches the target without entering the threat's lethal offset.

Missions	Success (✓)	Failure (✗)
Mission 1		✗
Mission 2		✗
Mission 3		✗
Mission 4		✗
Mission 5	✓	
Mission Success Rate	20%	

Figure 4-16. Mission Success Rate. Mission level simulation software, such as SUPPRESSOR, gives information on whether or not a particular mission would be successful.

The mission success table shows that five missions were attempted. The first four missions were unsuccessful because the P_k exceeded the threshold. This corresponds to a mission success rate of 20%.

Another way of representing the information presented in the mission success table is the deficiency table (Figure 4-17), which indicates which threats prevent us from putting targets at risk and provides the foundation for a quantified deficiency.

Threat	Targets at Risk	Goal	Deficiency
Threat A	100%	100%	0%
Threat B	40%	100%	60%
Threat C	20%	100%	80%

Figure 4-17. Deficiency Table. This table shows which threats cause the deficiency and so helps us to identify the kind of solution we will require.

Once we have the information presented in the mission success and deficiency tables, EWCEA analysts examine the unsuccessful missions to determine why they were unsuccessful and to quantify the deficiency. In other words, they need to identify how each threat's offset must be reduced to make the mission successful.

For example, was mission 1 unsuccessful due to threat A, threat B, threat C, or a combination of the three? If the mission failed because of threat C, would the mission have been successful if threat C's offset had been shrunk by 10%, 20%, or 50%? In other words, what reduction of the threat's offset would have allowed the aircraft to get to the target?

EWCEA analysts then aggregate the data from this analysis into a mission success table. This table shows the offset reduction we need to achieve for each threat to make each mission successful.

Missions	Required Offset Reduction (%)		
	Threat A	Threat B	Threat C
Mission 1	0	0	10
Mission 2	0	20	10
Mission 3	0	10	10
Mission 4	0	20	10
Mission 5	0	0	0
Total Solution	0%	20%	10%

Figure 4-18. Mission Success Table. This table shows the offset reduction we need to achieve to ensure mission success.

The mission success table gives us several important pieces of information about the threats in this sample scenario.

First, threat A did not present a problem during any of the missions; therefore, we do not need to explore any solutions to the threat posed by A.

Second, the table shows that we can achieve a 20% mission success rate against all of the threats with our existing technology (because the model demonstrates that currently one mission out of five will be successful).

Third, the table gives us a "total solution"—the offset reduction per threat that will allow us to get to every target. In this example, the total solution is:

- Threat A—0% offset reduction

- Threat B—20% offset reduction
- Threat C—10% offset reduction

In this section, the term solution refers to a specific combination of offset reduction percentages. It refers to a mathematical solution to attaining targets, not a physical solution.

Note that these total solution numbers are the highest offset reduction needed for each threat. If we could achieve a 20% offset reduction against threat B, we could avoid that threat on missions 1 and 5 (which didn't require any offset reduction of threat B), mission 3 (which required only 10% offset reduction of threat B), and missions 2 and 4 (which required the full 20% offset reduction of threat B). If we could achieve a 10% offset reduction against threat C as well, we could defeat all three threats on all missions. (Note that threat A posed no danger on any of the missions, so 0% offset reduction is sufficient to defeat threat A.)

These two pieces of information—the current mission success rate and the total solution—define what could be called a targets at risk (TAR) trade space. At the low end of this trade space, we know that we can currently put 20% of the targets at risk (that is, achieve 20% TAR). If we had EW equipment that gave us the total solution, we could put 100% of the targets at risk (that is, achieve 100% TAR).

	Required Offset Reduction (%)		
TAR	Threat A	Threat B	Threat C
20%	0	0	0
40%	?	?	?
60%	?	?	?
80%	?	?	?
100%	0	20	10

Figure 4-19. Incomplete TAR Trade Space Table. At the beginning of our analysis, we can define the outside borders of our trade space—what we can accomplish with no materiel solution and putting all targets at risk.

4.4.3 Create a Table of All Solutions

The incomplete TAR trade space table in Figure 4-19 gives us only two options—achieve 20% TAR or achieve 100% TAR. But a true trade space allows for many trades among variables. To define the trade space, we need to know what other solutions, or offset reductions per threat, would allow us to achieve the percentages of targets at risk between 20% and 100%.

Modeling tools allow us to quantify these other solutions. By constructing a table of all possible solutions, the modeler can determine the TAR value for every possible combination of offset reduction per threat.

Possible Offset Reduction (%)			Successful	Equivalent
Threat A	Threat B	Threat C	Missions	TAR
0	0	0	1	20%
0	0	10	2	40%
0	10	0	1	20%
0	10	10	3	60%
0	20	0	1	20%
0	20	10	5	100%

Figure 4-20. Table of All Solutions. With modeling and simulation tools, we can determine the relationship between reducing the threat offset and putting targets at risk.

The table of all solutions has been simplified for this example. First, the table gives offset reduction values in increments of 10 rather than in smaller increments. Second, the table does not show solutions above the "total solution" of 0-20-10, since these solutions would not result in any greater benefit to the warfighter.

To understand how this table is constructed, consider the fourth row, which has offset reduction values of 0-10-10. Offset reduction values of 0-10-10 would allow 3 successful missions—missions 1, 3, and 5. Therefore an offset reduction solution of 0-10-10 results in a TAR value of 60% (3 successful missions out of 5).

4.4.4 Create a Targets at Risk Trade Space Table

Once we have created the table of all solutions, we sort the values according to the targets at risk that result from various offset reductions. The completed table shows the relationship between each possible combination of offset reduction per threat and the corresponding TAR value.

	Required Offset Reduction (%)		
TAR	Threat A	Threat B	Threat C
20%	0	0	0
	0	10	0
	0	20	0
40%	0	0	10
60%	0	10	10
80%	—	—	—
100%	0	20	10

Figure 4-21. Sorted Table of All Solutions. This table shows the relationship between each possible combination of offset reduction per threat and the corresponding TAR value.

Figure 4-21, the sorted table of all solutions, provides the foundation for a completed trade space table, Figure 4-22, which indicates the missions we can accomplish against each threat with a given reduction in offset.

	Required Offset Reduction (%)		
Threat	0	10	20
A	5	5	5
B	2	3	5
C	1	5	5
All	1	3	5

Figure 4-22. Completed Trade Space Table. This table indicates the number of missions we can accomplish given an increase in offset reduction for each threat.

The completed trade space table allows us to determine what we gain in terms of TAR for an increase in offset reduction. In this example, the first thing we can learn is that any offset reduction above 20% does not provide any additional benefit to the warfighter. Additionally, when we have a sense of the relative costs of solutions, this table will allow the warfighter to decide whether the additional two targets put at risk by a 20% reduction in offset are worth the price differential between that solution and a 10% reduction in offset.

While the example we have used in this chapter is simple in several respects, it should indicate the benefit of the Military Worth Method for the warfighter and the acquisition community. In more complex examples, we would see even more clearly how the Military Worth Method allows us to compare alternatives and provide the greatest value to the warfighter.

4.4.5 Analyze the Mission Data

The Military Worth Method enables the EW acquisition community to determine how our solutions benefit the warfighter. Specifically, the method allows us to quantify what the benefit to the warfighter will be in terms of achieving additional targets.

Before the Military Worth Method, we recognized that threats A, B, and C might prevent us from reaching the target, but we could not quantify the severity of the threats. By answering questions that relate to specific scenarios and using modeling tools, we can quantify the effect of the threat as well as the contribution of EW solutions.

For example, if a jammer could achieve 50% offset reduction on all three threats, would it help the warfighter reach more targets? If so, how many more targets? Is 50% offset reduction the right amount of capability? Is it too little—or is it too much? If the jammer is extremely expensive, are we paying for capability that we don't need?

Today, with a Military Worth Method, modeling and simulation tools, and guides for disciplined decision making such as the TAR trade space table, we can answer these questions. The data from our sample scenario show that systems that provide the following capabilities would in fact be of questionable value to the warfighter:

- A solution that shrinks threat B by more than 20%.
- A solution that shrinks threat C by more than 10%.
- A solution that only shrinks threat B.
- A solution that shrinks threat A by any amount.

- A solution that achieves no more than 20% targets at risk.

In addition, the data allow us to see how trades between different capabilities would affect our final measure of targets at risk. This kind of specific, quantified information allows us to determine where to place the boundaries of the trade space as we set and convey requirements, and select, develop, and evaluate solutions.

4.5 Using the Common Tools and Measures That the Military Worth Method Requires

The Military Worth Method employs users with an array of tools that help us quantify deficiencies and demonstrate the contribution of EW systems to mission success. The military already uses three of the tools, though we have modified our use of them to reflect the Military Worth Method. The fourth is a quick-turn analysis tool that supplements modeling and simulation processes.

These tools support the Military Worth Method by:

- Producing high-fidelity results by combining warfighter input with existing tools
- Improving current tools with the Military Worth Method
- Performing quick-turn analyses
- Providing feedback to help improve existing threat models

4.5.1 Producing High-Fidelity Results by Combining Warfighter Input with Existing Tools

The Military Worth Method uses an array of tools, which are already in use by military analysts:

- Campaign level simulations
- Mission level simulations
- 1-v-1 simulations

Each of these simulations provides valuable information about the relationships between the threat, the planned mission, and the expected contribution of an EW system. The high-level analysis performed by campaign level simulations is fed into the mission level simulation, along with data about 1-v-1 encounters, and the mission level simulation calculates the percentage of targets at risk.

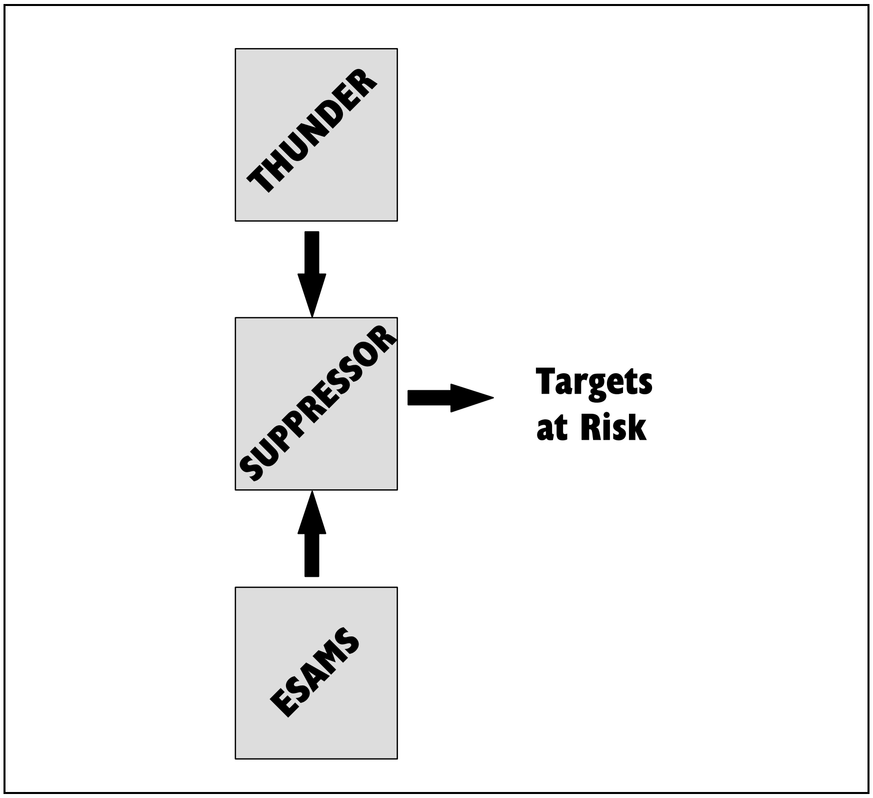

Figure 4-23. Relationship Among Military Worth Tools. Simulations perform different levels of analysis to produce a calculation of targets at risk.

Campaign Level Simulations

Currently, we use THUNDER, SUPPRESSOR, and ESAMS as our simulation tools. As better tools become available, we will employ them instead.

Campaign level simulations provide a comprehensive view of the military worth of all systems used in a campaign and can show us the net effect of EW systems as they are deployed in the field.

THUNDER, the campaign level simulation we currently use, plays out a conflict scenario over a number of days. The results show the effects of using and relocating resources, targets, assets, and threats during an actual military campaign. These simulations can also account for the addition of new forces and probable attrition. The data provided by THUNDER is fed into SUPPRESSOR, our mission level simulation.

Mission Level Simulations

Mission level simulations—we currently use SUPPRESSOR—are the primary means of calculating the military worth of EW systems. This type of software program focuses on campaign objectives, such as degrading or destroying a communications center. Based on results of actual campaigns, and using data provided by campaign level simulations and 1-v-1 simulations, mission level programs simulate missions based on the warfighter's actual flight plans, and then determines whether each mission would succeed.

1-v-1 Engagement Simulations

1-v-1 engagement simulations provide detail about specific encounters, which is fed into the mission level simulation to determine the success of particular missions. The 1-v-1 simulation we currently use is ESAMS, which calculates the probability distribution of being hit by a threat given a flight path history relative to that threat. Because they provide this level of detail, 1-v-1 simulations can also gauge the effects of an EW system, indicating the RiO achieved by a particular EW solution. ESAMS provides the P_k grids used to determine threat offset.

4.5.2 Improving Current Tools with the Military Worth Method

THUNDER, SUPPRESSOR, and ESAMS are all currently used. Our application of them for the Military Worth Method should improve the quality of simulation results, because we insist on using them only in conjunction with continuous warfighter input. Under the Partnership Process, analysts actively consult with warfighters to determine appropriate and accurate scenarios, targets, threats, missions, and flight plans.

All tools, and any calculations we perform with these tools, reflect the needs of the warfighter. Eventually, we expect to adopt improvements to current tools to make them object-oriented, open architecture models and simulations, a development that should help standardize our approach to modeling threats and the effects of military systems.

JMASS Tools

The DoD envisions that JMASS will provide an architecture for modeling tools in the future. As this architecture becomes available, the Partnership may be able to take advantage of the larger, common databases that such a framework will employ. While current tools are adequate to calculate the targets put at risk by EW systems, the DoD expects the implementation of the JMASS framework to provide more precise models and allow us to make more useful comparisons between competing types of systems.

4.5.3 Performing Quick-Turn Analyses

Implementation of the Military Worth Method will require a quick-turn analysis tool that allows frequent assessments of changes in system and component performance. A quick-turn analysis tool should manage databases and perform reliable analyses of the effectiveness of EW systems. Primarily, the quick-turn analysis tool should help decision makers quickly assess the impact an EW capability might have on mission success and decide whether higher fidelity analysis is necessary.

Higher fidelity analysis should be performed if:

- We need to make decisions involving large amounts of money, such as the decision to proceed past a milestone.
- We require more insight into a problem than the analysis provided by the quick-turn analysis tool.
- The quick-turn analysis tool indicates a high degree of uncertainty about its results.

A quick-turn analysis tool can calculate targets at risk with simplified engagement models. While this type of tool does not give the high-fidelity results other mission level simulations do, it provides almost immediate answers to users. This is a sharp contrast to traditional simulations, which can take months to run a full-scale analysis. Another function of a quick-turn analysis tool is that, because it runs from a widely available database, it keeps the most current data available for all decision makers.

Quick-turn analyses can prevent what we fear most—canceling a program after spending years and millions of dollars on its development, because the final product does not meet a specific point requirement.

A quick-turn analysis tool can provide several benefits to all participants in the EW acquisition community. For example, when a contractor's system does not meet a particular specification, we can use this tool to apply insight to understand the impact. By entering the contractor's new specification into the quick-turn analysis tool, decision makers can immediately determine whether the changed specification has any significant impact on mission success. If not, the contractor's solution is still valid. In the past, when we operated with specific point requirements, a contractor's system that did not meet a specification would have been rejected.

4.5.4 Providing Feedback to Help Improve Existing Threat Models

Modeling and simulation tools are constantly evolving as technology improves. Users can influence how tools improve by actively providing feedback to developers on the information they need. Through user interface, improvements in threat models can focus on providing information specific to military worth.

In particular, we aim to improve the usefulness of 1-v-1 models by incorporating test results. The 1-v-1 engagement level has two parts—the new EW system and a threat system. As our understanding of military worth improves and we gather new test data, we must ensure that:

- We capture any aberration from the modeling.
- We determine what caused an aberration.
- If necessary, we correct the models to reflect our new understanding of either the threat, our solution, or both.

For more information about the Silver Bullet program, see Section 10.3.2, Conduct Pre-Test Analysis.

One method for gathering this data so that it can provide feedback to our models is the Silver Bullet program, an innovative approach to synthesizing test data with digital models.

4.6 Assessing the Military Worth of Different Missions and Platforms

The Military Worth Method has been applied in the case of a strike aircraft. It is also readily adaptable to a variety of other missions, even missions where targets at risk is not the appropriate campaign-level measure of effectiveness.

The key to this flexibility is that the method's primary task is to determine how successful we are at getting an aircraft to a particular point in space. Consequently, the Military Worth Method can be used for:

- Strike
- Reconnaissance
- Airlift
- Special operations

In each case, the measure of military worth is based on accomplishing the objective in the ATO for that platform.

4.7 Making Military Worth Assessments Throughout the Acquisition Development Cycle

The greatest value of the Military Worth Method is how it drives and focuses decision making throughout the acquisition cycle. We first apply the Military Worth Method when we determine warfighter needs and quantify the deficiencies in current systems that prevent warfighters from completing missions.

After the deficiency has been quantified, the relative worth of a potential solution is compared to the deficiency baseline to measure the effect on the deficiency. In this way, we see how the solution contributes to mission success. Because of the Military Worth Method, we can be sure that solutions that do not have a direct and positive effect of mission success will not be considered.

Part Two of this document shows how the Military Worth Method is applied throughout the acquisition process.

Part Two of this document (Chapters 5 through 10) shows how the Military Worth Method will be applied to EW acquisition under the Partnership Process. These chapters guide you through all phases of the acquisition process, from quantifying mission deficiencies through evaluating the result.

In particular, Part Two of this document covers the following major activity areas of an acquisition:

- Chapter 5, Quantify Mission Deficiencies, provides an expanded and realistic example of quantifying warfighter needs.
- Chapter 6, Establish the Requirements, outlines how the quantification of military worth helps us establish requirements that respond to warfighter needs.
- Chapter 7, Convey the Requirements, describes how we communicate our military worth needs to our industry partners.

- Chapter 8, Select the Source, shows how the Military Worth Method helps decision makers validate and evaluate the solutions proposed by industry.
- Chapter 9, Develop the Solution, discusses how we continually assess the military worth of a developing solution and use this discipline to help us converge on an optimal solution to warfighter needs.
- Chapter 10, Evaluate the Result, illustrates how test and evaluation verifies that chosen solutions help warfighters succeed in more missions, and so proves their contribution to campaign objectives.

4.8 The Future of Military Worth

For a description of how the Military Worth Method can be implemented today, see the Process IPT's Audit Trail.

The Military Worth Method described in this chapter can be applied immediately to a variety of missions and EW solutions. As the Military Worth Method and supporting technologies develop, we hope to improve its value to the acquisition and warfighting communities. We want to make the Military Worth Method more robust by:

- Filling in gaps in the current method
- Making the operational capability measure more representative of EW solutions
- Defining a measure to more fully capture the voice of the warfighter
- Addressing suitability requirements

Any improvement to the current method must meet the same criteria met by the current approach—we must be able to use the improvement as part of a consistent measure, and solutions must be testable.

4.8.1 Filling in Gaps in the Current Method

For the Military Worth Method to provide the greatest benefit, it must provide a measure that allows a variety of solutions to compete with each other. At the moment, we can measure the effect of self-protect measures. The first priority for improving military worth is adding these other solutions:

- Airborne threats
- Electronic attack and electronic support

- Support jamming
- Situation awareness
- Lethal SEAD
- Decoys
- Non-EW solutions

Airborne Threats

We would like to apply the Military Worth Method and the RiO measure to air interceptors (AIs) to account for EW's effectiveness in air-to-air combat. This situation poses particular challenges, since both aircraft are moving and thus modeling the encounter requires an infinite number of P_k grids to capture the range and angles that may be continuously changing in three dimensions.

Adding AIs to the Military Worth Method will entail choosing some of the more common ranges and aspects and freezing the geometry for evaluation, and, at least initially, keeping velocities relatively constant. Despite the fluid geometric aspects of an air-to-air engagement, we feel we can limit the set of P_k grids and still achieve some degree of confidence in the accuracy of the measure.

AFSAA analysts are looking at ways to quantify deficiencies based on enemy AI capabilities. For now, we must wait for this capability.

Electronic Attack and Electronic Support

The Military Worth Method can currently identify the contribution of electronic protect (EP) solutions. Another new capability that we expect to achieve in the future is the evaluation of electronic attack (EA) and electronic support (ES) solutions. This is a fairly straightforward problem and should be quickly incorporated into the Military Worth Method.

Support Jamming

Support jamming differs from other electronic countermeasures because it employs both stand-off and direct support aircraft to shrink many threat rings in a particular area. Support jamming helps strike aircraft complete their missions. It does not directly place targets at risk; instead, it allows strike packages to do so.

This difference in roles, however, does not have much impact in the application of the Military Worth Method. The major differences are:

- Targets at risk are computed for the entire set of strike assets in the scenario, not just for one aircraft with a new self-protection system.
- Offset reductions for many threats must be modeled simultaneously.

As a result, we need to modify our approach to modeling, simulating, and testing jammers. We need to ensure that their contribution to mission success is accurately measured within the context of an entire scenario.

But one of the real benefits of the Military Worth Method is that, once we have the appropriate models in place, we can calculate the positive effect of jamming and so make an insightful decision about their value. These aspects of the Military Worth Method will make it relatively easy to employ the method for this class of solutions in the future.

Situation Awareness

Military worth has specific implications for situation awareness (SA) systems. These systems provide information about threats and non-threats in the vicinity of the subject aircraft. Usually, they identify other combatants and communicate relative bearing and approximate range.

As with jammers, situation awareness allows warfighters to avoid threats by:

- Staying away from the threat's engagement zone
- Maneuvering an aircraft to increase their probability of survival

We expect to enhance the Military Worth Method to assess the contribution of situation-awareness systems in the future.

Lethal SEAD

Lethal SEAD—suppression of enemy air defenses by destroying or disabling the threat systems—has some similarities to stand-off jamming from a military worth point of view. It has the direct effect of completely eliminating the threat that is encountered, and the indirect effect of taking out other threats when operators react by shutting down their systems.

Assessing the military worth of lethal SEAD requires a model of threat interactions, both direct and indirect. Once a model of lethal SEAD effects is available, determining targets at risk will be the same as with the support jamming case.

We expect to use military worth to assess the contribution of lethal SEAD to mission success in the future.

Decoys

Decoy systems are a class of self-protection EW that require some new analysis to understand their effect on P_k. Such analysis can be done today—it has not yet been performed because the system is still very new. The reason for this is that decoys do many of the same things that conventional on-board jammers do, but they also do one thing that no other countermeasure would—they attract the threat.

Attracting a threat may result in more shots, but aircraft supported by decoys can penetrate closer to threat sites because the shots are drawn away from the aircraft by the decoy. As a result, models that predict P_k grids must take this interaction into account when we study decoy effectiveness. Situation awareness capability is also a factor in decoy effectiveness because reducing P_k requires an optimization of the aspect angle between the decoy and the platform.

We can incorporate decoy systems into the Military Worth Method with current models and tools once we appropriately model the decoy-threat interaction and calculate the resulting P_k grids. Since we have this capability, we should incorporate decoys as soon as possible.

Non-EW Solutions

Allowing EW solutions to compete with other types of solutions such as stand-off weapons has been a major goal of our work to define military worth. In the future we hope to apply the Military Worth Method to these other solution types. Quantifying the military worth of some solutions is more straightforward than others.

While this work is outside the scope of our efforts, we hope to extend the applicability of the Military Worth Method to encompass all types of solutions.

4.8.2 Improving the Operational Capability Measure

The measure we use at the operational capability level is reduction in low-kill offset for each threat at a specified encounter probability of survival. This measure was explained in Section 4.3.3, The Role of Low-Kill Offsets and P_k Grids. The benefit of this measure is that it allows the warfighter to understand the geometric effect of EW systems and permits mission planners to move platforms past threats within the constraints of managed attrition.

The disadvantage of using RiO as the operational capability measure is that it does not account for a reduction in P_k that may result in conjunction with or instead of offset reduction. In other words, some EW systems may reduce P_k without having any effect on offset, and RiO does not reflect this benefit. See Figure 4-24 to compare the RiO of different EW solutions.

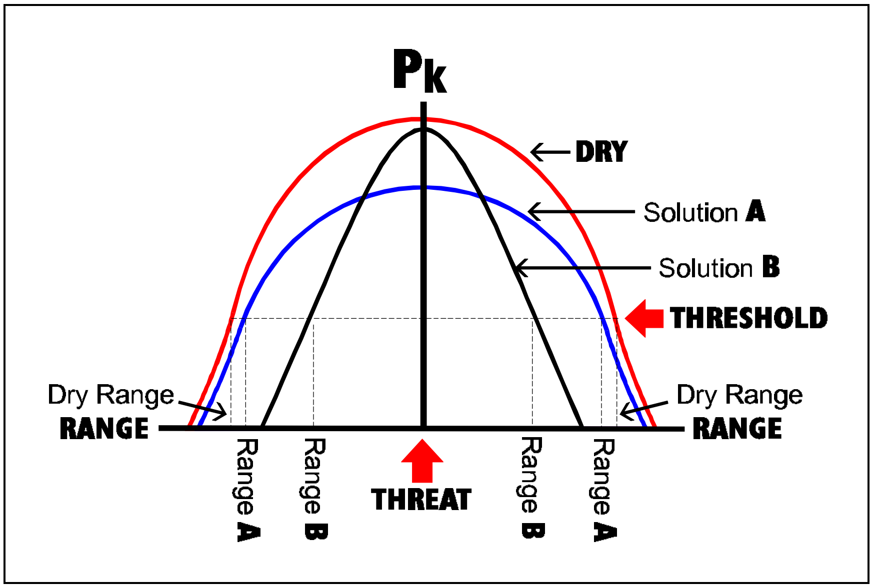

Figure 4-24. Comparison of the RiO of Different EW Solutions. Solution A reduces P_k when the aircraft is in close range while solution B provides additional range.

EW solutions can have various effects on the size and shape of the curve drawn between P_k and the range of the threat. Offset reduction measures only a decrease in the range of a threat for a given P_k threshold. In the notional graph above, for example, RiO reflects only a change along the bottom axis. In this case, solution B would be considered the better solution since it increases the space in which an aircraft can fly with an acceptable P_k.

But offset reduction does not account for the change produced by solution A, which reduces P_k without reducing the threat's offset. In many cases, solution B is preferable, since missions will not be planned if they exceed the P_k threshold. But if a mission must be planned, and we must accept an encounter with the threat, solution A may provide the better alternative.

In a more mature measure of military worth, we hope to account for both the reduction in offset as well as reductions in P_k that do not reduce the threat's offset. We plan to support additional work on this measure to better capture the dimension of P_k magnitude reduction.

4.8.3 Defining a Measure to More Fully Capture the Voice of the Warfighter

As we improve our understanding of the three principle factors of military worth and evolve the tools and methods we use to analyze warfare, we hope to more fully characterize the complicated interrelationship of these factors and how they affect the value of any single weapon system.

In this way, we hope to develop a single measure that captures the function of all three factors. Changes that maximize our confidence level, however, do not eliminate the gaps we discussed in Sections 4.8.1 and 4.8.2.

Part Two of this document focuses on the current state of the Military Worth Method, which holds time and resources constant and allows the warfighter to make objectives attained the only variable. Each step in the acquisition process described in Part Two of this document shows how to apply this definition of military worth to a process that ensures we provide a beneficial solution to the warfighter.

In addition to showing an EW system's contribution to achieving objectives, a future implementation of the Military Worth Method may show an EW system's effect on the resources and time needed to prosecute that campaign.

Articulating the Functional Relationship Among the Three Dimensions of Military Worth

As discussed in Section 4.1.2, Conceptualizing Military Worth, we need to have a single measure of military worth to have a useful tool for acquisition. Currently, we achieve this single measure by making one factor (operational objectives achieved) variable and constraining the other two (resources expended and time required). The following describes what needs to be accomplished before we can describe this function:

- Resources expended: Any future method that handles resources in a variable manner must recognize the complexity of this dimension—we would need to decide which resources are significant and calculate the effects of opportunity costs (resources that are expended which are not available in other parts of the campaign).
- Time required: A future version of the Military Worth Method may allow us to treat time as a variable. To move to this state, we would need to develop methods that could treat the entire campaign in a continuous fashion and show the dynamic effects of a solution on the overall amount of time required to prosecute the campaign.

These improvements depend on advances in our understanding of the factors of military worth. Attaining this higher level of confidence requires specifying the functional relationship between the three dimensions of military worth. In addition, we must await development in analytical tools and technology.

When these advances occur, we must ensure that the new tools are used by the warfighter to model campaign level ATOs. Field acceptance of new insights must precede any change in our approach to quantifying military worth.

4.8.4 Addressing Suitability

Due to time constraints during the initial development of the Military Worth Method, we were not able to address the part of military worth that relates to suitability—including factors such as the reliability of a system and its logistics footprint. In the future, we want to pursue the suitability issue and factor suitability requirements into our measure of military worth.

The following are some preliminary ideas about how to incorporate suitability into the Military Worth Method:

- Perform more detailed scenario analysis and a more thorough strategy-to-task breakdown. Currently, we perform analysis based on the performance characteristics of an EW system. In the future, we need to analyze from the standpoint of suitability to account, for example, for the effects of where aircraft are based in a particular scenario.
- Understand linkages of suitability to objectives achieved, resources expended, and time required. Additional work is required to determine the relationship of suitability to the factors we have identified as part of military worth. In particular, the functional relationship between objectives, resources, and time may need to include suitability as another factor.

4.8.5 The Future of Military Worth: A Summary

The following table describes the current status of the Military Worth Method and how we hope to improve it in the future. The steps described in the left column are discussed in greater detail throughout Part Two of this document.

Step	Current Capability	Possible Future Improvements
1. Gather scenario and threat data (Chapter 5)	Using input from the warfighter, we perform an analysis of the strategy-to-task breakdown	No change
2. Contact CINC to gather OPLAN and attrition (Chapter 5)	Fix attrition at a very low level	Factor resources expended (whose key component is attrition) into the military worth measure
3. Run campaign level simulations to identify force dispositions during key time slices (Chapter 5)	Use THUNDER	Use object-oriented, open architecture models Use automated mission planning tools to evaluate dynamic effects of time
4. Retrieve JFACC ATOs to determine target and asset matches	Ask warfighter for input on how assets in a particular scenario	No change

Step	Current Capability	Possible Future Improvements
(Chapter 5)	would be deployed against targets	
5. Gather detailed mission plans (Chapter 5)	Contact mission planning cells	No change
6. Run 1-v-1 engagement simulations to create relevant P_k grids (Chapter 5)	Use ESAMS	Use object-oriented, open architecture models and tools that account for the military worth of other EW and non-EW solutions
7. Run mission level simulations to determine baseline (objectives not achieved) (Chapter 5)	Use SUPPRESSOR	Use object-oriented, open architecture models and account for time required and resources expended in the military worth measure
8. Evaluate non-materiel solutions by repeating the strategy-to-task steps to identify materiel deficiencies (Chapter 5)	Return to step(s) 2, 4, and/or 5 to investigate different attrition levels, tasking assignments, or mission plans	No change
9. Document remaining deficiencies in the MNS (Chapter 5)	Deficiencies stated in terms of objectives not achieved, holding resources and time constant	Mission needs stated in terms of measure that captures all factors of military worth
10. Convey results to industry (Chapter 6 and 7)	Distribute modeling tools, threat data, and operational requirements	Involve industry in FME
11. Determine platform survivability level (Chapter 8)	Determine P_s for use in RiO by threat based on constant attrition level	No change
12. Gather industry proposals (Chapter 8)	Receive DSMs, P_k grids, and cost/schedule estimates of proposed solutions	Allow for other types of EW and non-EW solutions Use improved measure that accounts for overall reduction in P_k
13. Run mission level simulations to determine how many additional missions can be accomplished for each industry proposal (Chapter 8)	Use SUPPRESSOR	Use object-oriented, open architecture models

Step	Current Capability	Possible Future Improvements
14. Perform vertical AoA and award a contract (Chapter 8)	Set ORD objectives and thresholds and pick best solutions	No change
15. Develop test article and corresponding digital system model (DSM) (Chapter 9)	Use disciplined approach to manage change in cost, schedule, and military worth	Use quick-turn analysis tools
16. Compare result of test article with prediction (Chapter 10)	Use DSMs to analyze and evaluate a system's military worth	No change
17. Update DSMs with results of test and evaluation (Chapter 10)	Input test data into DSMs	No change
18. Run 1-v-1 engagement simulation to create new P_k grid (Chapter 10)	Use ESAMS	Use object-oriented, open architecture models
19. Run mission level simulation to determine effect on objectives achieved (Chapter 10)	Use SUPPRESSOR	Use object-oriented, open architecture models

Figure 4-25. The Future of Military Worth. This table indicates the future improvements we may pursue.

Summary

This chapter discussed the concept of military worth for EW systems, the benefits we expect to derive from the Partnership's Military Worth Method, how we apply the method to an acquisition, and our ideas for improving our approach. In the next six chapters, we will explore the major activity areas of EW acquisition, and illustrate how we will do business in the future.